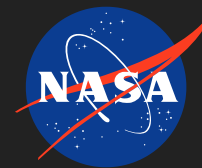


Direct hydrogenation of CO₂ to ethylene

Completed Technology Project (2017 - 2021)



Project Introduction

Minimization of the launch mass for long-term space missions will require the establishment of sustainable manufacturing techniques that use raw materials sourced through in-situ resource utilization (ISRU). Carbon dioxide gas (CO₂) is a readily available carbon source on space missions, but methods to transform it into more valuable chemicals are currently severely limited. Hydrogenation of CO₂ is a particularly attractive transformation in the context of space exploration because the other necessary reactant, hydrogen gas (H₂), is accessible via electrolysis of water. However, industrial CO₂ hydrogenation chemistry is limited to the production of C₁ products that are of low synthetic value. The proposed research project will investigate a novel method to effect the direct hydrogenation of CO₂ to ethylene (C₂H₄), which is a valuable feedstock chemical used in the industrial production of polyethylene (PE) plastics. If optimized, this chemistry could enable the production of PE for on-site manufacturing in space. The proposed CO₂ hydrogenation process uses no solvents or transition metal catalysts, and is instead catalyzed by an alkali carbonate hydrate salt (M₂CO₃·xH₂O). Preliminary results show that subjecting an alkali carbonate to a mixed atmosphere of H₂ and CO₂ at elevated temperature and pressure can result in a mixture of products including carboxylate salts and modest quantities of ethylene. This research seeks to improve the rate and selectivity of ethylene formation through a combination of mechanistic studies and process optimization. Key goals include a thorough elucidation of the reaction mechanism, optimization of the initial salt composition and reaction conditions for ethylene production, and design of a high-pressure flow reactor system that allows for precise, real-time control over the reactant mixture composition.

Anticipated Benefits

The proposed research project will investigate a novel method to effect the direct hydrogenation of CO₂ to ethylene (C₂H₄), which is a valuable feedstock chemical used in the industrial production of polyethylene (PE) plastics. If optimized, this chemistry could enable the production of PE for on-site manufacturing in space.

Direct hydrogenation of CO₂ to ethylene

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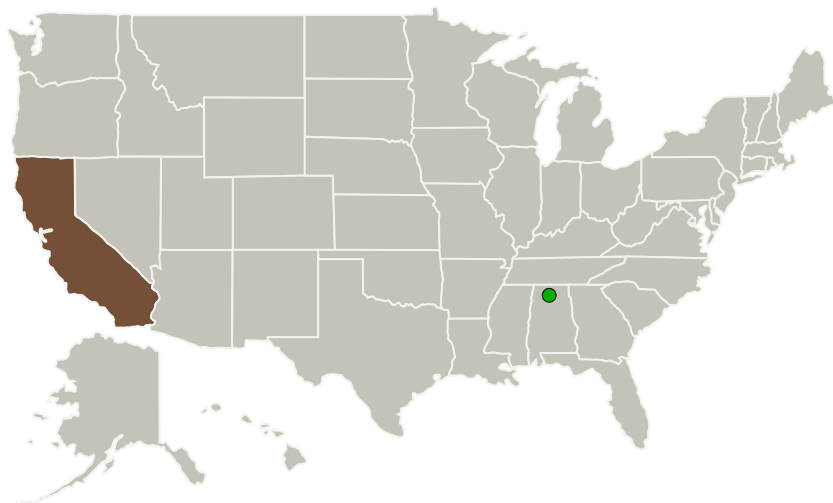
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Direct hydrogenation of CO₂ to ethylene

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Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Stanford University(Stanford)	Lead Organization	Academia	Stanford, California
● Marshall Space Flight Center(MSFC)	Supporting Organization	NASA Center	Huntsville, Alabama

Primary U.S. Work Locations

California

Project Website:

<https://www.nasa.gov/strg#.VQb6T0jJzyE>

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Stanford University (Stanford)

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

Matthew Kanan

Co-Investigator:

Amy D Frankhouser

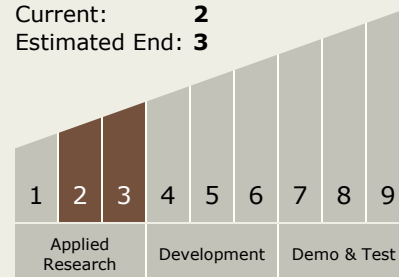
Direct hydrogenation of CO₂ to ethylene

Completed Technology Project (2017 - 2021)



Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **3**



Technology Areas

Primary:

- TX07 Exploration Destination Systems
 - └ TX07.1 In-Situ Resource Utilization
 - └ TX07.1.3 Resource Processing for Production of Mission Consumables

Target Destinations

Earth, The Moon, Mars